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ABSTRACT

Originally prepared for the Science Council of Canada, this document summarizes issues and concerns discussed by participants in a colloquium on content in Canadian science education. The meeting was prompted by the Report of the Commission on Canadian Studies which indicated, among other findings, that Canadian scientists and technologists fail to take into account the unique nature of Canada when doing their work. Four major issues were identified during the session: (1) the lack of attention to Canadian dimensions and problems in science teaching and research; (2) the failure of Canadians to recognize that science and technology are integral parts of our society's culture; (3) the need for increased public awareness of the roles played by science and technology in Canada; and (4) the attitude of young people toward science and technology. This publication includes the Commission's report and some responses to it, science education as a neglected area, and such related issues as the science curriculum, history of Canadian science and technology, transdisciplinary studies, publishing, teacher education, interdisciplinary scholarly communication, and the need for public awareness. (Author/DC)

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A Canadian Context for Science Education

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A Discussion Paper
Prepared by
James E. Page

SCIENCE COUNCIL OF CANADA

SE 036 385

October 1979

A CANADIAN CONTEXT FOR SCIENCE EDUCATION

A Discussion Paper

prepared by James E. Page

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The most valid and compelling argument for Canadian studies is the importance of self-knowledge, the need to know and to understand ourselves.

To know ourselves we must have an understanding and appreciation of the enormously important role played by science in our lives and in the formulation of our values and viewpoints.

From Professor T.H.B. Symons, To Know Ourselves: The Report of the Commission on Canadian Studies.

Table of Contents

Foreword 7

I. Introduction 9

II. The Relationship of Canadian Studies to Science Education 12

III. The Findings of the Commission on Canadian Studies 15

IV. Some Responses to the Report 22

V. Science Education As a Neglected Area 24

VI. Related Issues 25

- Canadian Studies and Science Curriculum 25
- The History of Canadian Science and Technology 29
- Transdisciplinary and Cooperative Studies 33
- Publishing and Canadian Science Education 35
- The Education of Teachers 41
- Interdisciplinary Scholarly Communication 43
- The Need for Increased Public Awareness 45

VII. Conclusion 48

FOREWORD

Given its responsibility "to assess the scientific and technological resources, requirements and potentialities of Canada...," it was inevitable that sooner or later the Science Council of Canada would turn its attention to the health of science education. That circumstance occurred in October 1979, when, at its seventy-second meeting, the Science Council approved a major study on Canadian Science Education. This study will examine the education system to determine the extent to which it:

- enables all students to achieve a basic level of science literacy and thus understand the impact of science and technology on their society;
- provides all students with a basic grounding in the history of science and technology in Canada;
- prepares those students who choose to enter universities or community colleges, for post-secondary studies in science and technology.

In view of the paramount importance of science and technology to developed nations and the growing appreciation that a healthy economic future depends heavily on a continuing flow of highly educated young people, this study may well be one of the most significant ever undertaken by Council. Work will begin early in 1980, and one of the first steps will be to seek discussion with, and the cooperation of, the individuals and institutions with a direct involvement in science education.

A Science Council decision to begin a new study is not taken lightly, especially as Council resources are limited and so many questions in the field of science and technology policy are clamouring for attention. In this case, a Council-sponsored colloquium, discussions with representatives of the science education field, and several

months of research work under the auspices of the Council Working Group on Science Education, preceded Council's decision.

This publication, A Canadian Context for Science Education, a discussion paper prepared by James E. Page, played a key role in convincing Council to consider seriously a study of science education in Canada, and led it to establish the Working Group. Early in its deliberations the Working Group decided the paper deserved a wider audience: hence this publication, which is intended for circulation amongst all those concerned with science education and, more generally, with the scientific health of the nation.

Mr. Page makes his position perfectly clear - if this society is to deal effectively with its future, then a citizenry able to comprehend science issues is essential. With precision and clarity, he presents strong grounds for believing this essential goal is likely to elude us until there is reappraisal of, and change in, our science education system. His views and arguments are both disturbing and thought provoking, and thoroughly deserving of the attention of the science education community and policy makers in the field of education.

It must be stressed that the views expressed in this discussion paper are those of the author and not those of the Science Council or its Working Group on Science Education. At present, Council has no collective view on this matter. Within the near future, however, it undoubtedly will have a view, and quite likely will make policy recommendations. Hopefully, many of those who read this paper will be prepared to make a contribution in assisting Council to arrive at well informed views and sound recommendations.

James M. Gilmour
Director of Research
Science Council of Canada

INTRODUCTION

Canadian studies, as a field, has received a considerable amount of academic, governmental and public scrutiny over the past several years. Perhaps the most important catalyst was the publication in 1975 of the first two volumes of the Report of the Commission on Canadian Studies. This Report lay at the heart of a science education colloquium convened by the Science Council of Canada in October 1978. Entitled "A Conversation about Canadian Content in Science Education", the colloquium provided participants with an opportunity to discuss science education with Professor T.H.B. Symons, chairman of the Commission on Canadian Studies and author of the Report. Participants in the various workshops identified a number of pressing concerns for science educators. The purpose of this paper is to explore those issues in an introductory manner and to suggest initial responses to them.

Major areas of concern identified by the colloquium participants were the lack of attention to Canadian dimensions and problems in science teaching and research, and the failure of Canadians to recognize that science and technology are integral parts of our society's culture. Another fundamental issue cited by the group was the need for increased public awareness of the roles played by science and technology in Canada. These concerns are related, in some ways, to a fourth issue of considerable interest to the colloquium participants-the attitude of young people toward science and technology. As a study

by McNarry and O'Farrell study indicated,[1] and as some colloquium participants confirmed, there appears to be a gradual swing away from the sciences on the part of young people when making career choices on entry into our colleges and universities. Much more study needs to be done, but it is possible that this swing is the result of a misunderstanding of the true role played by science and technology in our society: the result of beliefs that science is the servant of military and industrial complexes; that science is divorced from culture; and that, of the two great themes of human activity, aesthetic creativity is more benign than science and technology.

There are no easy answers to these fundamental concerns. Effective solutions will require the mobilization of large numbers of people, and significant commitments of energy and resources by a host of governmental, educational and private sector agencies and institutions. Further, there is no unanimity as to the proper solutions. This fact alone points to the need for solid evidence on each issue and for strong leadership, able to coordinate the various tasks which undoubtedly will be required.

Perhaps the most significant result of the Science Council's colloquium was a firm statement by those present that adequate recognition of a Canadian context for science education ought to be a basic educational objective. If Canada is to deal effectively with its future, then a citizenry able to comprehend science issues is a necessity. This goal will be possible only if our present and future scientists are critically aware of the impact their research and teaching can have on Canadian society, and only if the general population understands the important relationship between science and society. Only then, for

1. L.R. McNarry and S. O'Farrell, Student Attitudes Towards Science and Technology, Canadian Association of Physicists, Study Group, Ottawa, January 1971, 75 p.

example, will we, as a nation, be able to press for suitable science policies, research priorities, and funding practices.

Professor Symons, in his summary of the workshop discussions, suggested that if we fail, as a society, to face these issues we will be culturally poorer and will lack direction and purpose in our decision making. We will continue to underestimate the contributions and abilities of the Canadian scientific community and, hence, will continue to underutilize our scientific talent to the detriment of both Canadian scientists and the nation as a whole. Moreover, less than our best contribution will be made to the international pool of scientific knowledge.

II THE RELATIONSHIP OF CANADIAN STUDIES TO SCIENCE EDUCATION

In June 1972, the Commission on Canadian Studies was established by the Association of Universities and Colleges of Canada (AUCC), with the financial support of the Canada Council, the Science Council of Canada, and several independent foundations and donors. The chairman of the Commission, Professor T.H.B. Symons, was asked to consider and make recommendations upon the state of teaching and research about Canada in Canadian universities. Professor Symons believed strongly that a report on Canadian studies would be incomplete if it did not at least address the important question of whether or not teaching and research in the sciences were related, in appropriate ways and to an appropriate extent, to Canadian circumstances.

> "To omit a discussion on science would be to ignore one of the most important influences shaping the character of Canadian life." (I:141)[2]

Clearly, the science community was interested in the Commission on Canadian Studies for Professor Symons received representations from

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2. In this paper, references to the text of the Commission's Report will be to the unabridged, original version of the document, not to the abridged publication, The Symons' Report, McClelland and Stewart, Toronto, 1978. References will be made in the following way: (I:141) refers to volume I, page 141 of T.H.B. Symons, To Know Ourselves, the report of the Commission on Canadian Studies, Volumes I and II, Association of Universities and Colleges of Canada, Ottawa, 1975.

more than 50 scientific associations and some 500 scientists personally made their views known. In addition, many scientists and others interested in science-related matters sent briefs and made informal submissions on diverse subjects. (I:142)

Perhaps more than anything else, the attitude of some laymen and scientists to the relationship between science and Canadian studies underscored the need for the Commission to speak out strongly in favour of a Canadian context for science and education. The view that Canadian studies is a term which ought to be applied exclusively to the arts, letters and the social sciences, to human and socio-economic questions, was expressed often. Those with this conviction maintained that to speak of Canadian science or of Canadian engineering was inappropriate; that science and technology transcend all national boundaries, and consequently cannot be national in character. (I:142)

As a consequence, the Commissioner took great pains to emphasize that it is the imperative for a society to know itself in regard to questions of science education and science policy. " ... science, of course, is international in character," but he went on to say:

> "Nonetheless, the Commission believes that it is misleading to suggest that because science is universal, it does not have a national or cultural dimension ... .
>
> "To know ourselves we must have an understanding and appreciation of the enormously important role played by science in our lives and in the formulation of our values and viewpoints." (I:142)

In Professor Symons' view, it is ironic that, at a time when Canadians are trying to comprehend the forces shaping their lives, two basic elements and pervasive influences on our lives - science and technology - are almost completely ignored. As problems in such areas as food supply, the environment, population, energy, transportation, and communications multiply, science will be both a key to the solution and the creator of new problems.

Clearly, to know ourselves as Canadians we must be aware of the roles played by science and technology in our culture and society, as well as the impact of these elements on Canadian business and on our economic life. In appropriate ways, and to an appropriate extent, scientists in Canada must be aware of this society's needs, circumstances and characteristics. Similarly, all Canadians must become consciously aware of the impact of science and technology on their social, economic, physical, and cultural environments if they are to make informed decisions about the future.

III THE FINDINGS OF THE COMMISSION ON CANADIAN STUDIES

Even though this paper is concerned with the question of science education, per se, it is crucial that Professor Symons' findings be viewed in the context of overall observations on the state of science research, teaching, publication, and financing. Consequently, it should be stressed that the Commission's examination of science was not confined to the chapter entitled "Science, Technology, and Canadian Studies". There are sections in other chapters, notably those devoted to the university curriculum, to the community colleges, to the professions, and to archives, that also contain important observations and recommendations of relevance to this paper.

As a result of its research the Commission found that, on many occasions, Canadian scientists and technologists failed to take into account the unique nature of this country when doing their work. It found, too, that particular Canadian needs and concerns have been largely ignored in science teaching, research, and publication.

The limited resources of the Commission prevented preparation of a comprehensive inventory of those topics receiving inadequate attention or being ignored altogether. Despite this, Professor Symons and his colleagues have provided a shocking catalogue of neglect. Some of the examples are:

"We have by far the world's greatest continental shelves. We ought to be the world's leading oceanographers, but we are not. We ought to excel in arctic research, but we do not. Possessing as we do one of the world's greatest storehouses of mineral wealth, we ought to excel in materials preparation and metallurgy, but we do not ... ." (I:145)

"... despite the fact that Canada has the largest storage of fresh water in the world, there is nothing even remotely resembling a school of aquaculture at any university.

"... although our continental shelf equals about 40 per cent of our land mass, ... efforts to produce fundamental information relating to such matters as ocean floor topography, major currents, ice distribution, and weather forecasting at sea have been almost totally neglected." (I:146)

"... [there is] need for universities to devote more attention in both teaching and research to questions relating to Canada's enormous land mass.

"... geology might well be described as the neglected science in terms of the amount of attention it is receiving when contrasted with its importance to this country." (I:147)

"In zoology little research has been done on most Canadian mammals.

"... [There is] lack of priority given by university science researchers and teachers to problems relating to environment, to resource management and especially to conditions resulting from Canada's northern location ... Canada is failing to manage her resources properly because many of those responsible for resource management have been trained in techniques developed in other countries with warmer climates ... almost all Canada's university-level courses on ecology, on resource management, and on organisms are based on course materials originating in the South... only a few universities are conducting serious research into permafrost or ice ... ." (I:148)

"... few impact studies have been published concerning the mining industry. Nor have the serious problems of waste disposal under northern conditions yet been adequately researched ... . And yet, as one scientist has remarked, 'the beaches of some of our remote arctic islands are littered with plastic bags of human excrement grounded ashore after drifting from some northern outpost of our culture'." (I:149)

Though the catalogue is, as Professor Symons suggests, far from complete, it goes on and on at depressing length. And it is not restricted to a specific discussion of science and technology for, as the Commission notes in commenting on the state of education for the professions:

> "... only recently has graduate training in forestry been available at Canadian universities, and basic research requirements in this field are still not being met ... . Nursing in Canada, both at the undergraduate and graduate levels, continues to rely almost exclusively upon textbooks published in the United States ... there is an excessive reliance upon imported techniques or content in many branches of such professional science programmes as agriculture, engineering and architecture and building sciences ... in many professional scientific fields, there is a serious lack of trained personnel (for example, marine scientists and marine engineers) to deal with problems of special interest to Canada." (I:148)

From all of this, it is evident that Professor Symons' concerns about the neglect of Canada in scientific research and teaching are well founded. A number of reasons for this neglect are identified by the Commission. The major ones are:

1. The widespread belief that science is universal in nature and should not be restricted by national boundaries and considerations.(I:133)

2. Serious psychological barriers created by "academic snobbery, reluctance to deal with the obvious, excessive deference to the priorities of prestigious scholars and institutions in larger metropolitan societies." (I:133)

3. The assumption that when Canadian academic interests, priorities and values differ from those elsewhere, they are necessarily inferior. (I:133)

4. Assuming, at least, some degree of correlation between citizenship and/or academic background of a teacher and her/his research and teaching interests, the presence of a large number of foreign academics holding positions in Canadian university science departments must be considered a factor. Statistics Canada reports that in the 1976-77

academic year, 36 per cent of geographers, 33.5 per cent of mathematicians, 33.5 per cent of zoologists, 28.6 per cent of geologists and 26 per cent of biologists teaching in Canadian universities were not citizens of Canada. In the sciences overall, three out of ten university professors, or 29.7 per cent of those teaching in Canadian university science faculties, are not citizens of Canada, a situation unparalled in the developed world!

5. The use of imported technology, techniques and methodologies, whether suited to Canadian needs or not, is another factor. (I:132) The Science Council's recent background study, The Weakest Link, called Canada's R & D effort "the worst in the western world."[3]

6. As in other areas, science seems rigidly disciplinary in orientation, consequently denying science students opportunities to learn about their country's history, politics, sociology, etc. (I:145)

7. A lack of Canadian textbooks and excessive reliance on non-Canadian teaching materials in a broad range of areas. (I:159)

8. Existing severe government restrictions on funding for scientific research in Canada. (I:169)

9. A lack of transdisciplinary study and research opportunities in graduate and undergraduate curriculum. (I:154-158 and I:172)

10. Concealment of research results which leads to waste and needless duplication. Further, the reluctance of some scientists to become involved in areas of research that might be short lived, or might not advance their careers, or might involve areas in which important data are being withheld. (I:153)

But perhaps the most important reasons isolated as factors contributing to the neglect or the misunderstanding of Canadian science were related to education. The Commission concluded that scientists and laymen alike fail to consider science in a uniquely Canadian context and, on the whole, are unappreciative of the cultural role played by science. They have never thought about science in an

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3. Britton and Gilmour, The Weakest Link: A Technological Perspective on Canadian Industrial Underdevelopment, Background Study 43, Science Council of Canada, Supply and Services Canada, Ottawa, 1978, p. 81.

integrative way and have never been exposed to these considerations at any level in their formal schooling.

Consequently, the Commission stressed the parallel needs to equip undergraduate students in the sciences with a better knowledge of contemporary and historical Canadian society and to equip non-science students with a better knowledge and understanding of the importance of science in our society. (I:151)

> "... the vast majority of university and college (arts) students are scientifically illiterate! This situation is perpetuated as many of these graduates, in turn, become teachers and/or parents. For students in non-science courses the problem, essentially, is that not enough attention is being given at the post-secondary level to the provision of general education concerning the sciences; ... . Moreover, most textbooks suitable for use in such general science courses are published in the United States and deal with American themes." (I:151)

> " The converse is also true ... . The dean of one graduate faculty in the sciences reported that ... 'We find a general lack of awareness - often bordering on ignorance - among most students entering this programme, of contemporary and historical Canadian society. They have too little understanding of what I call the 'social dynamic of Canadian society' and too little understanding of the structure of our society, including its institutions and the nature of functions performed'." (I:152)

In making these points, the Commission on Canadian Studies reiterated what the Senate Special Committee on Science Policy had observed,

> " ... the standard and quality of life in this country will be largely determined by the way in which the people and their institutions respond to the prospects and perils of the application of science and technology."

The conclusion is obvious. If Canadians are going to support science in Canada, they must appreciate its importance and must not fear it. If scientists are going to use their skills appropriately to address Canadian problems, they must come to the realization of the

importance of these problems, and must be encouraged to think of science as an integral part of the culture of this country. For scientists and laymen must understand the Canadian aspects of science and technology if, collectively, Canadians are to make responsible decisions about their society.

From the foregoing it might appear that the prime responsibility for these educational shortcomings rests totally at the door of the universities, but as the Commission pointed out other levels of education ought to encourage their students to think in a more integrative way. For example, 95 per cent of high school students will never take university science courses. In most provinces, students selecting careers in the technologies will attend "community colleges" rather than universities. Although clearly elementary and secondary school and community college curricula ought to reflect these needs, the Commission found that they do not. The Commission recommends that, for example, community colleges undertake a thorough review of their curriculum (II:64). And even though the Commission's detailed examination of elementary and secondary education has not been published as yet, Professor Symons, in the science and technology chapter, concluded that Canadian school children learn virtually nothing about the "accomplishments and impact of science in their own country. And the reason is they are not being taught such matters." (I:162)

Nonetheless, even though the responsibility for teaching about Canadian science is shared by all levels of education, the Commission pointed out that the teachers, whether their students reach university or not, are, in most instances, themselves products of the university. Therefore the universities have a vital role to play in teacher education. Change must occur in the universities if future generations are to be served properly.

Another responsibility exists as well. Improving the curricula of the schools, community colleges, and universities will have an impact on present and future students. But what about those people who have completed their formal schooling? Given the magnitude of the food - energy - ecology - population - waste - urbanization - conservation problems which we face, there is an urgent need for an informed public, acutely aware of issues in the sciences, and interested in governmental policies, corporate practices and foreign influences on Canadian scientific efforts and capacity. A major thrust to increase public awareness of the role and the importance of science must be launched. Various formal and informal adult education strategies need to be assessed in addition to changes in traditional curricula.

IV SOME RESPONSES TO THE REPORT

Professor Symons and his colleagues drew to the attention of all Canadians the extent of the neglect of teaching and research about Canada in various areas, including science, and suggested ways to address the problem.

Already, to their credit, a number of governments, governmental agencies, universities, colleges, associations and schools have responded and many thoughtful individuals have been moved to act as well. Several of the major responses to the Commission's Report deserve notice here:

- Nearly every university in Canada has established a committee of its Senate or other senior academic body to examine, and make recommendations on, matters in the Report relevant to them.
- The Department of External Affairs has established, on the recommendation of the Commission, an advisory body on Canadian studies abroad, and has initiated a number of support programmes to advance Canadian studies in the US, the UK, France, Germany, Italy, and Japan among others. Expenditures on these activities totalled in excess of $400 000 last year.
- Many other bodies, such as the Association of Universities and Colleges of Canada, the Association for Canadian Studies, and the Association of Canadian Community Colleges have established intra-association committees for the same purpose.

- In late November 1978, the Department of the Secretary of State announced a programme of financial support, totalling more than $1 595 000 over the next three years, for the Association for Canadian Studies, the Canada Studies Foundation, and the Association of Canadian Community Colleges, to help these groups respond to issues of concern to them and their members.

- The National Film Board of Canada (NFB) has completed a major study of the implications of the Commission's Report for the NFB's production and distribution arms. The board has released a 110-page annotated film guide on the types of NFB materials available to enhance Canadian studies work in the classroom. This book is being distributed to 10 000 teachers.

- The Canadian government has amended the Medical Research Council Act so that the Council is no longer excluded from supporting public health research relevant to Canadian conditions.

- The National Research Council has set up a new programme of national interest grants to encourage and assist scientists at Canadian universities to undertake research specifically related to problems of national importance.

- The Canada Council has set up a nine-member consultative group to examine the function and state of the Canadian archival system and the implications of Canada Council programmes for the development of Canadian archives.

- Students at the University of Calgary have endowed a chair of Canadian studies.

It is obvious that the Commission on Canadian Studies is having a profound impact on Canadian education and research. Having called for fundamental reform of the education system, the Report has led to major new initiatives.

V SCIENCE EDUCATION AS A NEGLECTED AREA

Although responses have been made, many of the recommendations have not been addressed. Examples that bear directly on science education are:

- The history of Canadian science and technology is still a neglected field.
- The March 1978 hearings of the Task Force on Public Awareness of Science and Technology in Canada made it obvious that crucial issues have yet to be addressed.
- Statistics drawn from one provincial ministry of education indicate that the number of students taking courses in "science and society" or "science in a social studies context", is even lower now, proportionately, than when the Symons' Report was published. For example, one grade 9-10 offering, "Man, Science and Technology", had the following enrolments:

Year	Number Enroled	Number of students in grade 9-10 province-wide
1975	1 315	311 145
1976	875	310 952
1977	124	311 447

  As well, decreased enrolment was reported in other social studies of science courses.
- Major gaps in the development of textbook materials reflecting Canadian issues, concerns, and circumstances still exist in many areas.

VI RELATED ISSUES

Canadian Studies and Science Curriculum

The findings of the Commission in the area of science education uncovered an almost unparalleled story of neglect and missed opportunities. A number of specific observations about science education in the universities are germane. The Commission reported that science students," showed a general lack of awareness - often bordering on ignorance ... of contemporary and historical Canadian society." (I:151-152) In order to provide science students with an opportunity to learn more about their society and the role played by scientists in Canada, Professor Symons recommended:

1. Courses be made available, at least as options, to enable all science students to study the history, institutions, and the social and cultural frameworks of their society, and also to examine the role of the scientist in this society. (I:153)

2. Much greater emphasis be placed on Canadian aspects of science activity in Canadian universities. (I:153)

3. Work be done to discover ways in which university research and teaching in the sciences can be related to Canadian problems and opportunities. (I:153)

4. Both the public and government be encouraged to recognize that universities cannot meet this challenge without substantial additional financial support. (I:153)

5. Universities should provide more opportunities for science students to gain experience in cooperative and transdisciplinary

studies and research. (For more on this subject, see pp. 33). (I:172)

6. Increased academic recognition and financial support be extended to teaching, research and publication concerning the history of science and technology in Canada, and curricula be developed. (I:173)

As already noted, the Commission on Canadian Studies found that, "the vast majority of university and college (arts) students are scientifically illiterate!" (I:151) Its findings were similar to concerns expressed in the Canadian Association of Physicists' (CAP) report, Student Attitudes Towards Science and Technology.[4] The CAP report, funded in part by the Science Council, drew attention to two important and related phenomena, namely, that the negative attitude toward science and technology expressed by a number of young people was resulting in a swing away from the sciences. As a consequence, in time our society will be less equipped, than even at present, to deal with important science-related issues.

> "Those who have no scientific understanding are cut off from a great human activity; and may well feel excluded from intercourse with those who have such understanding ... ."[5]

> "It is emphasized that people in a democratic society do use science; and that this use, to be effective, requires a knowledge of what science is, and of what it can do."[6]

> "The decline in the interest of young people in physics is part of a long-continued drift away from sympathy with science and technology."[7]

The findings of the Commission on Canadian Studies show that between 1971 and 1975 little had occurred to change the CAP report's

4. L.R. McNarry and S. O'Farrell, Op. Cit.
5. Ibid., p. 6.
6. Ibid., p. 3.
7. Ibid., p. 3.

negative appraisal of students' attitudes. Further research needs to be done, but the implications for Canada, and for science, of these findings is extremely disconcerting. The Symons' recommendations, consequently, assume the tone of an imperative. The Commission recommended:

> "Serious consideration should be given to requiring all non-science university students to take an introductory course in science that would give them some basic knowledge and understanding of the part science plays in our culture and society; at the least, such a course, well-planned and of good academic standard, should be available at every university as an option open to students not majoring in science." (I:171-172)

Some work of this kind is being done by a few universities and colleges. The Science and Human Affairs group at Concordia University has worked closely with faculty from McGill in a Collaborative Studies programme. Courses have been established on modular bases. The written support materials are being re-worked at present. Perhaps the Concordia-McGill model is one which might be used as an example. The SISCON (Science in a Social Context) approach being experimented with in Britain is another model which might be adapted for use in Canada. The SISCON method is based on a series of workbooks which are used as guides for seminar and tutorial work, rather than for independent study. Perhaps a similar Canadian content series for post-secondary education should be developed.

A recent curriculum review by one university shows that science and non-science students are not yet being given the kinds of study opportunities which Professor Symons indicated were required. This review, done in 1977, reported a lack of sensitivity to Canadian studies and Canadian content. The physics department reported: "We doubt that any program <u>per se</u> could be identified as strictly Canadian ... [although] ... in certain directions such as atmospheric research and geophysics and biophysics, there is potential for development."

From the botany department came word that, "... none of the courses are specifically related to Canada ... there has been no change in emphasis [on Canada] over the last five years ... . There is certainly a need for more intensive studies in Canada, in relation to various botanical subject areas. Lack of money is a problem." Similar comments came from this university's chemistry, zoology and microbiology departments. The review illustrates that even in an interested university, little progress had been achieved in the sciences.

The elementary and secondary school curriculum is, of course, another area of concern. Although Dr. Symons' chapter on Canadian Studies in the Schools is not published yet, he made it clear that Canadian school children:

> " ... learn of the accomplishments and impact of science in other countries, ... but they learn virtually nothing about the accomplishments and impact of science in their own country. And the reason is that they are not being taught such matters." (I:162)

A quick review of the curriculum offerings of several provinces indicates that Dr. Symons' observations are still accurate, in fact, as the enrolment statistics cited on page 24 indicate, the situation may have worsened. More study should be done.

Obviously, all of these post-Commission findings indicate that curriculum problems in science education are still present, and are perhaps even more pressing. A systematic study of the neglected areas and a thoroughly considered plan of action, which will address curriculum development needs from kindergarten through to the graduate level, is required.

Since Canada has no national ministry or even an office of education, a national body, concerned with the state of science and science

education, is needed to facilitate action. Some steps that ought to be considered are:

1. The commissioning of a Canada-wide study to review curriculum offerings in the sciences with a view to determining the degree to which they relate scientific knowledge and applications to Canadian situations.

2. This review ought to include an assessment of the importance of providing a basic "science literacy" component in all levels of curriculum programmes.

3. Levels of student interest and involvement in subjects that deal with science in a social studies context should be examined to determine how curricula can be designed to inform young Canadians of, and interest them in, the relationship between science and society.

4. In cooperation with curriculum specialists, guidelines for the development of appropriate curriculum should be formulated.

5. The Commissions' findings and the recommendations related to science education need to be drawn to the attention of the scientific community, the universities, the community colleges, the ministries of education, and other appropriate bodies with recommendations for action.

6. Based on the findings of the Canada-wide study mentioned previously, the AUCC, the ACCC, and the Council of Ministers of Education should develop a concerted plan of action for consideration and possible implementation.

7. Funding needs to be found for the development of an integrated series of curriculum study units, perhaps of the SISCON variety, which can be used by students at the undergraduate non-science level. Consideration should be given to the development of similar kinds of materials for the schools and the community colleges.

The History of Canadian Science and Technology

In early November 1978, a conference on the Study of the History of Canadian Science and Technology took place at Queen's University in Kingston. The participants examined the state of the field, giving attention to such diverse topics as archives, museums, publications, funding, curriculum development, teaching materials, and so on. The

conference organizers had anticipated an enrolment of about 50, however almost 150 attended.

Despite the interest, it became clear from the papers that the study of the history of Canadian scientific and technical achievement is seriously underdeveloped. Speaker after speaker noted the extent of neglect in one or another aspect.

This situation is distressing because the history of Canadian science and technology is basic to a number of science education objectives. Without a clear understanding of this history and without well developed scholarship and a body of literature, then attempts to increase public awareness of Canadian scientific endeavour and achievement will be thwarted. Further, the possibilities for developing first-rate courses for students will not exist.

In its survey of the issue, the Commission on Canadian Studies concluded:

> "There is little appreciation, for example, of the very significant role that Canadian scientists and technologists have played in the development of many aspects of oil technology, electrical engineering, metallurgy, refrigeration, agriculture, transportation, communications and nuclear reactor technology.
>
> "... [Canadians have] the impression that this country contributes minimally to science, that Canadian science has no history, and, indeed, that ours is a second-rate scientific community." (I:162)

There are a number of reasons for this neglect, reasons identified by the Commission and reiterated at the Queen's conference. These problems relate to teaching, research, and publication in the field of the history of Canadian science and technology.

> "First, and perhaps foremost, is the difficulty of finding a home in the university community for this field of academic work: neither historians nor scientists have quite welcomed or accepted

> it ... . Moreover, historians and scientists have been reluctant to recognize each other's work in this area." (I:163)
>
> "The second major obstacle to the development of historical studies in Canadian science is the lack of financial support for work in the field, particularly for critical analysis of the development and impact of science in Canada." (I:164)

In an article published in Science Forum, Professor Richard Jarrell wrote; "The more specific area of the history of Canadian science and technology is, perhaps, even more undeveloped than Symons suspects."[8] In his article, Jarrell makes the following points:

- There are a few biographies and a few special studies of specific sciences, government departments, or scientific education. Technological studies are almost entirely those that lean heavily to economic history or deal with historical sites in Canada.
- The thin body of literature results from a lack of manpower, which, in turn, is a reflection of the traditional educational patterns in Canadian universities.
- The history of science, as a professional study, is relatively young, and the history of technology still younger.
- Canadian content in the history of science and technology programmes at both the graduate and the undergraduate levels is "vanishingly small."
- There are only four departments of the history of science that actively pursue graduate studies: McGill, University of Toronto, University of Western Ontario, and l'Université de Montréal.
- The only schools with courses in Canadian science are Toronto (one graduate half-course and one undergraduate half-course, both offered occasionally), York (one course for part-time students every alternate year) and Western (the one course listed in their calendar has never been taught).

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8. Richard A. Jarrell, "Why Do Many Canadians Know Nothing of Canadian Science?" in Science Forum 56, Volume 10, Number 2, April, 1977, pp. 23-26.

- There are even fewer offerings in the history of Canadian technology.
- The history of Canadian science and technology has never been actively pursued by the learned societies such as the Canadian Historical Association or by the Canadian Society for the History and Philosophy of Science.
- In Canada there is no journal devoted to either the history of science or the history of technology.
- The federal government has taken almost no interest in supporting work in Canadian science history.

A number of the recommendations by Professor Symons and his colleagues address the problems identified by the Commission's Report and by Professor Jarrell in his article. Clearly, writing and research about Canadian achievements in science and technology and about the impact of science and technology on the development of Canadian society must be encouraged. This recommendation is fundamental to a solution of the Canadian science history dilemma.

Professor Symons emphasizes the need for greater understanding of the role played by science and technology in historical and contemporary Canadian society on the part of both science and non-science students alike. This need is not being handled effectively because the teachers of science are not well versed in history or social science themselves and are not able, or willing, to integrate their disciplinary work with considerations of past and present social contexts. There are too few historians of science, on the other hand, and those in the field often think in global, rather than in terms specifically Canadian. Nothing will be done in this field until there is a "meeting" of the disciplines involved and attitudes change. This will not happen until academic recognition and financial support are forthcoming. If assistance and/or encouragement were to come from such bodies as the Natural Sciences and Engineering Council, the Social

Sciences and Humanities Research Council, and the Medical Research Council, perhaps more Canadian graduate students would be drawn into this field from both the sciences and other academic areas.

At the same time of course, the Public Archives, the National Museum of Science and Technology, and the National Museum of Man must receive more funds to support proper management and expansion of collections and research resources. (I:174) In plenary session, the Queen's conference noted the need to develop rational and thorough acquisitions and preservation policies to ensure that absolutely vital historical records and artifacts are not destroyed or lost. Several truly horrible examples of the destruction of documents, or the sale, often to foreign buyers, of valuable historical materials were brought to the attention of the participants. With adequate funding these artifacts could have been saved and would certainly have contributed to our store of knowledge.

Transdisciplinary and Cooperative Studies

Obviously fields such as the history of science and technology depend for their vitality on transdisciplinary studies. This field is an obvious meeting ground for a number of disciplines from the sciences, social sciences, and the humanities. Transdisciplinarity is crucial to science in a Canadian context and in other ways as well. For example, as the Commission states, huge projects like the proposed northern pipelines and the James Bay hydro-electric project provide challenges requiring the cooperation of many disciplines, if the public interest in environmental, economic and social terms is to be served. (I:154) Our success in grappling with conservation problems, new energy developments, regional economic inequalities, with deindustrialization, and so on, will depend on our ability to bring to bear the best minds in the country from a host of disciplines.

The Symons' Report sets forth the case concisely. By trying to address such complex problems as environmental protection or energy innovation and conservation along disciplinary lines, the scientist working alone is impotent, as is the engineer, the economist, or the politician. Each can only propose a partial solution. Consequently, "... science policy, [for example] can hardly be conceived or implemented in isolation, but must be evolved in articulation with economic, social, educational and other policies." (I:154)

Clearly, social studies of science and technology, and basic science literacy subjects for non-science students must depend on cooperative studies such as those pioneered by the Collaborative Studies Group at McGill and Concordia. The struggle to make the public critically aware of the impact of science on their everyday lives will only be successful if information on science is presented in understandable language and if this information is related to daily problems. Science cannot be presented without consideration of the cultural, historical, economic, and social contexts if public awareness is to be fostered.

Despite the fact that transdisciplinary and cooperative studies are critically important in a complex society, the Commission on Canadian Studies noted that the universities are ill-prepared to work in this way. In fact there are barriers that block interdisciplinary work. (I:155)

1. Our education system is almost exclusively devoted to teaching and assessing individuals on the basis of work conducted in isolation.

2. Recognition, status and advancement in the sciences are highly discipline-oriented and largely dependent on peer evaluation within one discipline.

3. The bias against transdisciplinary and cooperative approaches in research in the sciences extends to teaching as well.

4. The rigidity of some federal funding policies and procedures, and especially the reluctance to make funds available for integrative work in the sciences, are additional obstacles to the development of transdisciplinary and cooperative approaches to Canadian studies in the sciences.

5. Currently, a substantial amount of transdisciplinary work tends to be ineligible for grants from federal award-granting agencies because their granting policies are oriented toward work in particular disciplines rather than to work that crosses disciplinary lines. This barrier has been strengthened by budget cutbacks which force an even greater focus on 'core' aspects of research support responsibilities. For example, the Centre for Settlement Studies at the University of Manitoba (applauded by the Commission for its excellent work) has recently closed its doors, and the university has been forced to close the interdisciplinary Agassiz Centre for Water Studies as well.

The Symons' Commission recommended, among other things:

> " ... an immediate inventory and assessment of existing transdisciplinary research centres and institutes in Canada. Such an inventory would provide a useful overall picture...of developments in this field [and] would be helpful in indicating areas of neglect and of opportunity for additional transdisciplinary work." (I:157)

Clearly, such a study, by pointing out the successful work being done in a number of post-secondary institutions, could indicate models for the development of innovative approaches to research, teaching and publication, and may indicate useful strategies to increase public awareness of, and interest in, science and technology. It might also consider guidelines for appropriate funding of transdisciplinary study and research.

Publishing and Canadian Science Education

"The frequent unavailability of suitable textbooks and other academic publications with Canadian content is a major obstacle to the development of Canadian studies in many areas of science and technology". There are a number of cultural implications of this dearth of materials

as well, not the least of which is the collective Canadian impression that Canadians do not have a scientific heritage. (I:158)

The findings of the Commission regarding publication in the sciences in Canada are corroborated by the findings of the 1972 Ontario Royal Commission on Book Publishing, and by the more recent study, The Publishing Industry in Canada (1977), prepared by the Bureau of Management Consulting for the Arts and Culture Branch of the Department of the Secretary of State. In addition, some of the findings and observations of the report by the Royal Society of Canada, The Press of Knowledge (June 1978), bear directly upon the Commissions' findings on scholarly publication.

For example, the Royal Commission on Book Publishing noted that the division of sales to the university book market in 1972 was 87 per cent imported books and 13 per cent domestically-produced books and that there were " ... few Canadian-written university textbooks in mathematics, science, and engineering apart from those published by the international textbook houses... ."[9]

> " ... There are good reasons why Canadian society can defend a preference for Canadian teaching materials even in some subject areas ... not specifically Canadian (e.g., in science and mathematics), subjects which are often contrasted with the social sciences in this context. The thrilling epic of man's recent achievements in space, for example, should be treated objectively and treated honestly ... [but] these achievements should be evaluated in a Canadian context, or we shall end up by supporting a public education system which short-changes its own citizens in training.
>
> "Not only should important Canadian contributions in science, say, be told about in our textbooks, and told about in uncoloured perspective, but consideration could also be given to why satel-

9. Ontario, Canadian Publishers and Canadian Publishing, Royal Commission on Book Publishing, Queen's Printer for Ontario, Toronto, 1972, p. 130.

> lite communications have special significance for our country, domestically as well as internationally. New methods of meteorological forecasting that employ computer technology should use Canadian examples wherever they are appropriate... .
>
> "The study of ecology is concerned with problems and priorities which have at long last been recognized as international. But if this subject is to achieve its fullest meaning for Canadian students, it must be endowed with all of the Canadian relevance possible. The kinds of precautions needed to protect the environment against, say, oil spills in the Gulf of Texas or off the coast of California are important ... but similar problems in the Canadian Arctic or off the Pacific and Atlantic coasts of our country deserve equal or greater attention, surely. Pollution in all of its forms is a continent-wide and world-wide concern, but it is pollution in Canada which our textbooks should use as the base for discussion."[10]

It is important to note that the findings of the Ontario Royal Commission have been reflected in the 1977 study of the Canadian publishing industry by the Bureau of Management Consulting. In its report, the Bureau made clear that, in its view, book publishing "is both cultural activity and a business" and that books are "tools for education."[11] The Bureau found that foreign-owned publishers in Canada concentrated on the Canadian textbook market, particularly that of the elementary and secondary schools.[12] Foreign-owned publishing houses in Canada derived 59 per cent to 95 per cent of their sales from the education market[13] and 1176 of the 1440 titles (excluding mass market paperbacks) published by them in 1972 were textbooks.[14] On the other hand, Canadian publishers derived from

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10. Ontario, Royal Commission on Book Publishing, Ibid., pp. 194-195.
11. Bureau of Management Consulting, The Publishing Industry in Canada, A report prepared for the Arts and Culture Branch of the Department of the Secretary of State, Ottawa, 1977, p. 31.
12. Bureau of Management Consulting, Ibid., p. 71.
13. Ibid., p. 57.
14. Ibid., p. 62.

17.3 per cent to 40.7 per cent of their sales from education, while 742 of 3184 books, or 15.6 per cent of their titles were designed for the school, college and university textbook markets in 1972.[15] The implications are clear, " ... Canadian-owned firms do not compete directly with foreign-owned firms."[16]

When one couples this observation with the Ontario Royal Commission's findings that there is virtually no Canadian publishing of science textbooks, then the problems identified by Professor Symons are placed in high relief. As the Report puts it, " ... most Canadian publishers are apparently not much interested in topics related to science and technology." (I:161)

This situation has had a crippling effect on efforts to develop a Canadian context for science education. A review of the curriculum guidelines for Ontario elementary and secondary school science courses provides a striking case, which must be considered representative. Very few Canadian texts are suggested as readings for students and the guidelines do not reflect a Canadian context except in the most perfunctory way. Further, in discussions with curriculum coordinators in the Ministry it was made clear that, in their view, few recommendations on Canadian context were followed and they were, in large measure, "lip-service". The reasons given were: the lack of Canadian support materials; teachers have little or no training in "Canadianizing" their science curriculum; and science teachers, feeling pressured to prepare their students for undergraduate work at the university level, considered themselves under such time constraints that they could not bother with the "peripheral" matter of relating science to the Canadian context. The important point is that a lack of texts was cited as the major problem.

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15. Ibid., p. 57.
16. Ibid., p. 61.

In addition to the attitudes of Canadian publishers, the Commission on Canadian Studies noted a number of other factors contributing to a lack of Canadian publishing in the sciences. These factors should be noted as well:

1. The Commission found that among many scientists at Canadian universities there is still a lingering doubt about whether writing textbooks and helping to prepare other teaching materials is a legitimate area of activity. (I:160)

2. Many scientists still view publishing in Canadian journals as an "act of charity" rather than a worthwhile scholarly accomplishment or contribution. (I:160)

3. Many university presses and other publishers prefer to devote their attention to scholarly works which can be subsidized from federal or provincial funds. While social scientists and humanists are eligible for such subsidies from, for example, the Social Sciences and Humanities Research Council of Canada, no comparable support is available to aid the publication of scholarly books in the sciences.

4. The market in Canada for learned publications is limited because of the country's relatively small and scattered population (I:161). Commenting on this, the Royal Commission on Book Publishing noted that it is one thing to bring out an anthology of readings in sociology for freshman use in Canada only, and quite another to develop a basic textbook in medicine, engineering, or even international affairs without access to a continental or world market.[17]

Subsidies, promotional campaigns, more advantageous postal rates for Canadian scientific journals, and similar measures will undoubtedly help rectify the situation in science publishing, but the most important need is to organize the small Canadian market that does exist. Using as a model the excellent support in convening meetings given by the Science Council to forestry faculties when they sought to organize the small market in their field, the Commission recommended:

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17. Ontario, Royal Commission on Book Publishing, Op. Cit., p. 67-68.

> " ... Similar meetings in other fields, on a large scale and perhaps involving academics as well as policy makers, could do much to bring about stronger mechanisms and policies to support the publication and marketing of Canadian educational materials in the sciences." (I:162)

Perhaps the Council of Ministers of Education should be encouraged to help develop guidelines for science texts which would address Canadian needs and point to ways in which the Canadian market might be organized. MOSST might be encouraged to hold a series of meetings with representatives of the academic and scientific community, the publishing industry, the federal and provincial departments involved in relevant fields, and such bodies as the AUCC, SCITEC, the Royal Society of Canada, and the various discipline-oriented associations in Canada, to plan ways in which the serious textbook deficiency can be remedied. (Recommendation 23, I:173)

MOSST, in consultation with the award granting councils, the Science Council, and representatives of the university and the scientific communities, might examine ways to increase support for Canadian scientific journals and to expand the opportunities for the publication of Canadian scientific papers. (Recommendation 19, I:173) This recommendation has been echoed by the recent report of the Royal Society of Canada, The Press of Knowledge, a searching enquiry into the state of science scholarly journals in Canada.

> " ... without continued and strengthened support for research journals, Canadian science will be at a severe disadvantage in its efforts to serve national needs."[18]

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18. Royal Society of Canada, The Press Knowledge, a report by the Committee on Publication Policies and Practices for Research Journals and Other Periodicals in Science and Engineering in Canada, Ottawa, June 1978, p. 3.

The Education of Teachers

One of the major impediments to the development of a Canadian context for science education is that teachers are either unwilling or unable, or both, to deal with science curriculum in a Canadian context. Their unwillingness, when it exists, may stem from the fact that they have never thought about the issue, or it may be that they view teaching science in a Canadian context as simply one of a number of possible teaching strategies. It is likely, however, that teachers will react to what they perceive to be in the best interests of their students, and those interests are usually defined in terms of what is most likely to contribute to the students' preparation for college or university. If post-secondary educators in the sciences do not prize the students' abilities to relate science to Canadian situations, or if they do not consider it is important for students to have some knowledge of the history of Canadian science, then we cannot reasonably expect the vast majority of secondary school science teachers to be concerned either.

When considering teacher education in this context, we have little information on what will motivate teachers to adopt the teaching of science in a Canadian context. In any further study, teacher motivation and education should be one of the foci of the work.

There are a number of other potential issues as well. To teach science in a Canadian context, teachers will need various kinds of support to be effective. This is, after all, the case in any educational field. Nevertheless, there are several specific areas which can be isolated, including the actual training of teachers for

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Note: The author is indebted to Douglas A. Roberts, Associate Professor, Department of Curriculum, the Ontario Institute for Studies in Education, for his helpful comments and suggestions with this portion of the paper.

the classroom and the development of suitable materials for teacher instruction.

Due to declining enrolment, there is much less mobility within the teaching profession than there was in the 1960s, and there are fewer new hirings. Consequently, in addition to looking carefully at the training of new teachers, retraining must be considered. In short, both pre-service and in-service teacher education strategies will have to be developed. Both types of programmes should encourage teachers to understand, appreciate, and use crossdisciplinary and transdisciplinary techniques whenever possible. The concept of "team teaching" should be explored and boards of education should be encouraged to develop mechanisms, in terms of timetabling and space allocation, to permit team teaching of "science and society" courses.

Techniques for curriculum design are also worthy of detailed attention. Faculties of education must make a conscious effort to encourage design techniques and curriculum approaches that will support the development of science courses within a Canadian context.

Another fundamental area of concern for the education of teachers ought to be the development, selection, and use of curriculum materials. Clearly, this area has been so grossly ignored by the publishing industry that teachers in the sciences must be schooled in various ways to develop their own curriculum materials; materials that will relate the principles they teach and the problems they discuss, to local resources, industries, and to specifically Canadian problems and concerns.

In terms of "in-service" training, a number of organizations should be encouraged to support the "professional development" of teachers. For example, teachers' associations, federations, unions, and various subject-oriented associations, like the Environmental

Studies Association, should be encouraged to develop professional development programmes for their membership.

As well, consideration ought to be given to the development of a series of special teacher information packages which provide Canadian examples for the teaching of the sciences, and others which provide material on the impact of science and technology on Canadian society. Such packages, perhaps based on the SISCON model, might include sample curriculum units relating specific science problems to Canadian circumstances. Information on the various museums and archives from which learning materials can be ordered, or which are involved in science-oriented projects, might be included as well.

Interdisciplinary Scholarly Communication

Many of the areas of concern discussed in this paper can only be addressed if there is effective and continuing communication between scientists in various disciplines, and between the scientific community and humanists and social scientists. This is demonstrably the case in the development of histories of science and technology in Canada, as well as the development of appropriate "science and society" curriculum, especially at the undergraduate level.

The Commission on Canadian Studies, in the chapters of the Report devoted to the university curriculum and to science, technology, and Canadian studies, made the point over and over again that the obstacles to scholarly communication must be overcome if Canadian studies are to flourish. Major obstacles seem to be the excessive rigidity of disciplinary lines and the fact that advancement within the academic community takes place typically within a disciplinary department. As noted, a downgrading of cooperative and transdisciplinary work has resulted.

If Canadian students, at the university level especially, are to think of science and society in an integrative way, then the barriers between scholars and teachers in various disciplines must be breached. This is less of a problem in the schools and in most of the community college systems in Canada. Nevertheless, work needs to be done and the Science Council could have a vital role to play in removing these barriers.

> " ... The Commission commends the Science Council for the notable contribution it is making to Canadian studies in science and technology, and recommends that the capacity of the Council for critical and independent analysis and for building strong connections with all sectors of Canadian science be strengthened. (Recommendation 42, I:175)

In addition to this recommendation, the Commission made a number of explicit suggestions to strengthen scholarly communication. These suggestions, addressed to a number of quarters, include:

1. The development of a strong and active Association for Canadian Studies.

2. Support for newsletters, journals, scholarly publications, and bibliographic studies of value to transdisciplinary work.

3. A series of regional workshops on the teaching of Canadian studies courses in which information on existing programmes, for example course outlines and reading lists, could be discussed by faculty in participating departments.

4. Faculty exchanges in the field of Canadian studies to enable staff members to broaden their experience and to develop associations with scholars and teachers in other parts of the country.

5. Greater efforts to arrange and finance information-sharing and exchange programmes and workshops as a means of fostering curriculum development and planning, and of avoiding unnecessary duplication.

Because of the central role that the Science Council can play in furthering interdisciplinary scholarly communication, it is important

for Council to be aware of these various needs. It would be useful, for example, if the Science Council were to establish liaison with the Association for Canadian Studies to determine ways in which the two bodies might cooperate to encourage progress on this matter.

The Need for Increased Public Awareness of the Role Played by Science and Technology in Canadian Life

Several years ago, MOSST released a report entitled Science, Mass Media and the Public, which contained the results of a survey indicating that more than 80 per cent of the population over the age of 15 believe that it is important to be kept informed about science. Yet two-thirds of these people could not name one Canadian scientist. Two-thirds of those polled were interested in finding out more about specific Canadian achievements in science and in learning more about Canadians involved in science. Yet only 19 per cent could identify Banting and Best as Canadian scientists, or even insulin as a Canadian achievement.

Early in 1978, the Task Force on Public Awareness of Science and Technology, facilitated by the Science Council, held a "consultative" session to explore ways in which the public could become better informed about science, technology and Canadian society. At that meeting several important points were made by Dr. David Suzuki, and they warrant being repeated. He said:

> " ... the collective public ignorance about science is appalling. The wide acceptance and popularity of astrology, UFOs, ESP, Uri Geler, plant communication, the Bermuda Triangle, Pyramid Power, and Chariots of the Gods attests to a failure of the scientific method to penetrate everyday life.
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> " ... this ignorance is reflected in the media. If we were to judge the social status of scientists from their presence on television, for example, we would have to conclude their role is trivial. Scientists appear primarily to verify the efficacy of rectal suppositories, underarm deodorants and nasal sprays."

In his presentation, Dr. Suzuki explained how, in his view, an enormous gulf has developed between scientists and non-scientists as a result of the ever increasing specialization of science, the scientific explosion of the past decade, the tendency of scientists to use "jargon", and the reluctance of scientists to involve themselves in "popularizing" science, or in explaining to the public the results of their research. The implications of this ever-widening gulf between scientists and laymen is critical both for the future of Canada and the future of scientific teaching and research in this community.

The need to explain developments in science and technology, and to relate these developments to issues which Canada faces, has been highlighted by numerous commissions, task forces, and reports. Clearly, if the citizens of Canada are to be able to make informed decisions about these issues, if they are to demand public policies which are appropriate to their needs, then a long-term public education programme about science and technology is a necessity. As Professor Symons has said:

> " To know ourselves we must have an understanding and appreciation of the enormously important role played by science in our lives and in the formulation of our values and viewpoints." (I:142)

A number of strategies for public enlightenment have been discussed in Canada. Science programming, albeit limited, on the electronic media is a fact. There is support for a special association to foster communication between laymen and scientists, although it is important to note that the scientific community is cool to the idea. Activities comparable to the work being done at the UK's Open University have been suggested. The need for a science magazine in Canada which would appeal to the layman has been recognized. But despite all of the talk, woefully little is being done to increase public understanding.

Consequently, it would seem that a national body concerned with science ought to take the matter in hand and institute a number of specific programmes of public education in collaboration with other groups interested in this question. What seems to be required, in short, is an act of will. Despite the apparent reluctance of the scientific community to become involved in this effort, the need for public awareness is too great to be ignored any longer.

VII CONCLUSION

This paper was prepared to present an outline of some science education issues and to suggest initial responses. As the paper indicates, several fundamental concerns must be faced before action can be taken. People must be encouraged to consider an appropriate context for science education, and planners must know what is being done presently in the areas of Canadian science education, research funding, and publishing before intelligent strategies can be developed.

For these reasons, only two recommendations are made in this preliminary statement of issues. If acted upon, researchers, educators, politicians, and the public might be more willing to think about the relationships that exist between science and Canadian society.

1. A Special Study

For a clear picture of the current state of science education in Canada and some appreciation of the gaps that exist in research in the sciences on topics of special interest to Canada, clearly a national study of the extent of the neglect and ignorance must be undertaken. This study could deal with the various issues outlined in the previous sections of this paper, as well as with some of the policy and research questions raised by the Commission on Canadian Studies and referred to in Sections II and III.

2. National Conferences on Science Education

As a result of the recent Science Council colloquium on the Symons' Report, it is evident that a number of critical issues need to be drawn to the attention of educators, researchers, governments, and the public. To that end, a second initial step might be the organization of conferences on the various issues raised in this paper. The general goals of such conferences would be: to draw attention to the lack of a Canadian focus in a number of teaching and research areas which could, appropriately, have such an orientation; to discuss how this compromises Canada's ability to deal with national concerns and to contribute to international progress in a number of fields; and to encourage those involved in education and research to address these problems.

To elaborate on the idea of a special study, some of the following suggestions could be adopted as guidelines. It is clear from the findings of the Commission on Canadian Studies that there is a need for an inventory and an assessment of science curriculum to determine the extent to which Canadian issues and concerns are reflected in school, college and university teaching. As well, there is need for an inventory of the kinds of research being done in Canada in various sciences, and for a catalogue of the various topics of importance to Canadians now receiving little or no attention from the scientific community.

Because this study would be concerned primarily with education, consideration might be given to the preparation of an inventory of the opportunities available for transdisciplinary and cooperative study, teaching and research. Such an inventory could provide a number of useful models for future programme development and might shed more light on the barriers to this kind of work that exist in Canadian universities.

The study might include, as well, an inventory of the resources available in museums, archives, and private collections of value to science teaching and research. Special attention might be devoted to those collections that would aid the development of the history of Canadian science and technology. Related to this, the study might include an examination and assessment of current guidelines for the collection, collation and preservation of important historical materials, and suggestions might be made for future collection-building.

An examination of the various approaches taken to the development of "science and society" courses, and an assessment of the issue of "science literacy for general arts students" could be included in the study. An evaluation of the current state of science teacher education, with special attention to in-service programmes, might be appropriate as well.

A study of the state of Canadian science textbook publishing is long overdue. The Royal Society's recent study, The Press of Knowledge was devoted to periodical publishing. Various government studies have touched on the question of science textbook publishing, but no thorough examination has been undertaken. Because appropriate texts are crucial to the solution of many of the problems identified here, the time may be right to consider commissioning a thorough review of this aspect of the industry.

Finally, the important question of public education about science could be addressed. This portion of the study might include a survey of the implications of the inability of the Canadian public to deal with science issues, an assessment of current attempts to inform the public about science and technology, and a blueprint for future efforts in this area.

The proposed national conferences on science education, if handled properly, could do much to make the public, educators, scientists and politicians aware of the importance of the science-society relationship. It might be wise to consider such events only after completion of the special study because national conferences might be the best way to encourage a sector-by-sector review of the findings.

There are a number of additional potential purposes for national meetings. They could be organized to focus attention on some or all of the themes identified in this paper: the need to foster the development of the history of Canadian science and technology; various ways to encourage transdisciplinary and cooperative study; solutions to the science textbook publishing dilemma; ways to foster interdisciplinary scholarly communication; and so on.

In addition, it might be appropriate to have seminars, as part of the general conferences programme, for certain groups. For example, a special meeting of representatives of various private and public funding agencies might be called to encourage the establishment of national priorities for research into Canadian-related science and technology problem areas. Further, conferences might be used to establish special working groups to prepare, for example, a Canadian version of the SISCON units or to consider guidelines for in-service teacher training.

Finally, conferences could be used to initiate further liaison and collaboration between the various professional bodies and groups that have an interest in Canadian science education, or Canadian studies, or both. In this way, those most concerned could be encouraged to work together, for the first time in many instances, to solve some of the problems so graphically described in the Symons' Report.

A special study and national conferences on these issues would be but first steps to the solution of the very serious and deeply rooted problems described so briefly in this paper. Science education and public awareness of science and technology are linked, and it will take, minimally, a generation to turn our society's attention to the true impact of science on society and on culture. Although these recommendations are obviously initial steps, they are vital ones because they could lead to the first full airing of the issues related to science education within a Canadian context.